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BIOLOGY AND METAPHYSICS.

IN CONSIDERING the relation of science to metaphysics, assuming that each has a place in the scheme of human endeavor, I have urged the essential importance of distinguishing as clearly as possible the sphere of the one from the sphere of the other. No doubt such delimitation of subject-matter involves definitions of the terms "science" and "metaphysics" which are not universally accepted. Ambiguity on such a vital point would, however, be fatal. It is therefore essential that the exact meaning I attach to these terms should be stated, and if necessary restated, with clearness and frankness. The sphere of science, then, in the somewhat restricted sense I here advocate, is the universe of phenomena. The man of science deals with the realities of experience. Accepting these realities as data, the primal mode of origin of which, if they have such a mode of origin, it is not for him to consider, he traces the changes that they undergo, generalises the results, and gives them clear expression in terms of related antecedence and sequence. For him any event is explained when the conditions of its manifestation are laid bare, when its antecedents have been traced, and when it is referred to its appropriate category in the scheme of natural occurrences. On the other hand the sphere of metaphysics is that of noumenal existence; of the underlying cause of the observed sequences of phenomena; of the *raison d'être* of the universe which science has done so much to explain in terms of antecedence and sequence. Thus regarded science and metaphysics are nowise antagonistic; they are complementary the one to the other. But though the man of science can afford to ignore metaphysics, the metaphysician cannot afford to ignore science; for science provides him with the data of which it is his endeavor to render a final account. Whether man as a rational being can afford to ignore either is a matter of opinion.

Now it will no doubt be said that if this delimitation be accepted, the sphere of science, though it includes physical science and biology, fails to embrace mental science, psychology, ethics, æsthetics, and logic. Nothing, however, could be further from my intention than to suggest a delimitation which does anything of the sort. The data of mental science are, no less than the data of physical science, provided in and through experience. The perception of an object is every whit as much part of the realities of experience as the object of perception. Indeed they are the same item of experience regarded from different points of view. As I have before urged it is only by the analysis of experience that we distinguish its objective from its subjective aspect. And though it may to some sound strange to claim the data of mental science as part of the universe of phenomena, yet I shall endeavor to make good this claim in my next essay. For the present it must suffice to say that the phenomena which we group under the head of mind are included in the sphere of science which deals with them in terms of related antecedence and sequence, just as it deals with the phenomena which we group under the head of matter in similar terms. The sphere of science thus has two hemispheres—physical and mental respectively. The more clearly we distinguish them the better. For when idealism attempts to explain physical changes in terms of sensation or perception; and when materialism attempts to deal with mental states as the product of physical antecedents, there is no end to the confusion that results.

Even when this source of misunderstanding has been removed, there still remains a further criticism of the usage suggested. For "the study of the ultimate grounds of all knowledge and of all science of whatsoever kind—the science of *Epistemology*" is excluded. This *scientia scientiarum* which forms the subject of Dr. St. George Mivart's volume on *The Groundwork of Science* can find no place, it will be said, in the proposed scheme of delimitation. I believe, however, that it does find its true and legitimate place in the sphere of metaphysics. It deals, not with observed moves among the pieces on the chequered chess-board of experience, but with the question how there comes to be a game to be played, and, when this is settled, how the knights and pawns are moved each with a distinctive path across the board. This is a very different problem : one so different that it is well to distinguish it by name. Of course, if it be granted that the problems are different we may still broaden our definition of the term science so as to include them both. But it may be urged that finer and therefore sharper distinctions in terms are often helpful to clearer distinctions in thought. And if we can more readily keep our problems in separate intellectual pigeon-holes by thus giving them quite different labels, much confusion may be avoided, and precision of thought may be fostered.

In my last essay I discussed the question of vitalism in some of its aspects, and no doubt said many things which failed to carry conviction. Had they been generally admitted the saying of them would have been a work of supererogation. The essence of my contention was this : that if we grant to the vitalist all that he claims to have established, if we admit that living matter presents us with phenomena which are observed nowhere else in the known universe, these phenomena must be accepted as part of the data which it is the business of the man of science to elucidate in terms of related antecedence and sequence. If as man of science he be unable to explain in these terms the mode of genesis of the phenomena in question this may be because he has reached the limits of scientific interpretation ; and there he must leave the matter, and pass on to other problems. If on the other hand he invoke the conception of vital force not as the physical antecedent but as the underlying cause of the phenomena, let him do so frankly in the name of metaphysics and not of science. Metaphysicians will welcome any suggestions which he has to make in their special field of work. But they will remind him that not here only in the field of vital phenomena, but throughout the whole realm of nature, are there diverse manifestations of Force, as the cause of phenomenal changes; and that no matter where we probe beneath the surface of experience we find the variously selective modes of influence of this Force. The frosted pattern on the window-pane presents, in a different form, the same metaphysical problem as the fern frond to which it presents a superficial resemblance. If once the appeal be made by the man of science to metaphysical causes he must realise that not only here but everywhere are they in ceaseless operation.

The sketch of vitalism that was presented dealt only, however, with certain properties of living matter on which some stress has of late been laid. I purpose in this essay to take a somewhat wider survey of biological facts and their interpretation. From whatever point of view we regard the problem of life, we see in the simplest living organism a theatre in which the atomic and molecular characters enact a drama nowhere enacted in just this way on any inorganic stage. There is a continuous give and take both of matter and energy which is scarcely so much as hinted at elsewhere; there is a unified sequence of changes constituting a less or more complex life-history; and there is through the process of reproduction a continuous stream of sequence, of much wider range in time. In place of the short life-history of the individual, we have the indefinitely longer life-history of the species. These phenomena are so central for biology that it will be well to make them the starting-point of our further consideration of life-problems.

It is a familiar fact that so simple an organism as the *Amœba*—a mere speck of protoplasmic foam—presents in miniature, and in a far less complicated form than is found in the higher animals and plants, all the life-processes which are commonly regarded as essential. Here in the first place is that assimilation of congruous substances, food and oxygen, thus intimately incorporated with its protoplasm, which is one of the distinctive marks of all life. And here too is that not less distinctive process of partial disintegration. Only through disintegration of its substance does protoplasm give indications of its vital activity. In its absence there would be no sign of life. On the other hand, complete disintegration would result in decomposition, the mark not of life but of death. Between these extremes lies the mean of vital activity, shown in its essential features as clearly in the amœba as in man. Partial disintegration provides for change, the concomitant of activity, and for continuity preserving individual identity; while it renders necessary the process of assimilation by which the loss due to partial disintegration is made good, and by which through incorporation new substance is caught up into the stream of continuous individuality.

Is it a matter for wonder that the cause of these phenomena, seen in a microscopic speck of living matter, has been regarded as "a mystery transcending naturalistic conception; as an alien influx into nature, baffling scientific interpretation." And yet I believe that this attitude of mind is due, partly to a misconception of the function of scientific interpretation, and partly to influences arising from the course pursued by the historical development of scientific knowledge. The function of science is to formulate and to express in generalised terms the related antecedences and sequences which are observed to occur in protoplasm. This can already be done with some approach to precision and accuracy. There is at any rate little reason to doubt that this goal of scientific endeavor can be reached by an extension and refinement of scientific method. But the cause of the phenomena does not fall within the purview of science; it is a metaphysical conception. It is no more (and no less) a "mystery" than all causation throughout the universe of phenomena is a mystery. And if it be said that the origin of life on our planet cannot be expressed in scientific terms of related antecedence and sequence, this may be either admitted or denied according to the sense in which the words are to be taken. It must be freely admitted that we do not know the physical antecedents of the first speck of living matter that appeared on this earth; but it must not be admitted that this honest confession of ignorance implies that there were no such physical antecedents. It may be admitted that when life first appeared new modes of the interaction of material particles occurred; new data were afforded for science to deal with in accordance with its method of interpretation; but it must not be admitted that this necessarily implies an "alien influx into nature." Neither science nor metaphysics now believes in any such alien influx. There is nothing alien introduced into nature from without; all the influences at work are inherent in the fibre of her being. Or, if this metaphysical assumption be not accepted, if the doctrine of occasional influxes from without be an article of faith, it should surely be applied consistently. There are thousands of chemical compounds, each with a distinctive group of physical properties, found thus combined nowhere else in nature, which took their origin under appropriate conditions at successive points of time during the slow cooling of the earth. There may even have been a time in the long ago past, when the elements were still held separate in the fervent heat of the planetary vapor, when compounds had not yet had their origin in the history of this past of the solar system. If this be so, there must have been an epoch in evolution when these new data emerged for science to deal with, just as there was a later epoch in evolution when other new data, those presented by life, emerged in an analogous manner.

If the mystery of life, therefore, be said to baffle scientific interpretation, this is because it suggests problems with which science as such should not attempt to deal. The causes of vital phenomena (as of other phenomena) lie deeper than the probe of science can reach. But why is this sense of mystery especially evoked in some minds by the contemplation of life? Partly, I think, because the scientific interpretation of organic processes is so recent and in many respects so incomplete. People have grown so accustomed to the metaphysical assumptions employed by physicists and chemists when they speak of the architecture of crystalline forces and the selective affinity of atoms, they have been wont for so long to accept the "mysteries" of crystallisation and of chemical union, that the metaphysical causes have coalesced with the descriptions and explanations of science, and the joint products are now, through custom, cheerfully accepted as "natural." Where the phenomena presented by protoplasm are in question, this coalescence has not yet taken place; the metaphysical element is on the one hand proclaimed as inexplicable on naturalistic methods of interpretation, and on the other hand denied even by those who talk glibly of physical forces. But in due course of time this, too, will be commonly accepted as perfectly natural; and the battle will rage elsewhere.

Returning now to our amœba, in addition to the primary characteristics of concomitant or alternating integration and disintegration in a continuous and unified sequence, there are other secondary phenomena which are either the direct outcome of the primary characteristics or are intimately associated with them. Disintegration is associated with movements which, even in so lowly an organism, are to some extent in adaptation to the needs of its simple mode of life; and it gives rise to products, some of which must be got rid of as useless if not deleterious but some of which may be utilised to prepare the food for assimilation. It also under special conditions may give rise to a tough substance forming a protective layer or coat around the protoplasm. Thus by its life-processes the amœba produces excretions, that is to say waste products to be got rid of, and secretions, that is to say disintegration products which may serve a useful purpose. Lastly (for only certain leading features need be enumerated) the amœba presents the phenomena of reproduction in their simplest expression. A specialised part of the protoplasm, the nucleus, divides into two portions. According to some biologists the peculiar function of this nucleus is to control the reproductive process, using this phrase in a broad sense. What are the antecedent conditions which determine its division we do not fully know; but we do know that the division is the visible and seemingly related antecedent of a further change—the splitting of the whole amœba into two, which henceforth lead a separate life. This reproductive process is, however, so essential and so peculiar to life that it cannot be regarded as of secondary importance. It must take rank with the concomitant integration and disintegration as a primary characteristic. It opens the way to a divergence of continuous lines. It is distinctive of living matter and does not find a parallel in the inorganic world.

Attached to the stems of weeds and other bodies, may be found another microscopic organism which is also like the amœba a dweller in water. This is the Bell-animalcule or vorticella. Shaped like a translucent wine-glass on a long stalk it shows a very marked advance in structure on the amœba. Whereas the amœba has no definite mouth but can take in food-particles at any part of its substance, the vorticella has a funnel leading inwards towards its central substance. The rim of the wine-glass and the orifice of the funnel are provided with delicate waving cilia, so called because they resemble microscopic eyelashes composed of transparent living matter. Their constant movements set up currents in the water which draw in the minute fragments of animal or vegetable matter which serve for food and which, passing to the narrow end of the funnel, burst through into the inner substance of the vorticella. This substance like that of amœba exhibits the balanced processes of assimilation and disintegration. But, apart from the orderly play of the cilia, the movements are more clearly adaptive. On any sudden jar, or the introduction of an irritant, the long-stalk suddenly coils up through the contraction of a central fibre, the rim of the wine-glass is turned in, the cilia disappear from view and the expansive end becomes contracted and bunched up. There is a band-shaped nucleus, which in preparation for the reproductive process divides, half passing into each of the two individuals into which the vorticella shortly afterwards splits. But there is also observable from time to time a different process. Free swimming forms are budded off from the vorticella (with nucleus division) and these unite with other stalked individuals, the two nuclei fusing to form a new combined nucleus. And after this, the multiplication by the ordinary process of fission (or splitting into two individuals) goes on more rapidly and with increased vigor. So that vorticella exhibits a higher degree of differentiation both of structure and of orderly movements; it shows a process of conjugation, or fusion of nuclei preparatory to reproduction,—a process only occasionally observed in amœba; and, in general, exemplifies a more complex sequence of changes, constituting its life-history, and more delicate and definite adaptation of protoplasmic response to surrounding conditions.

Now if we place side by side on the same slip of glass an amœba, a vorticella, and the fertilised ovum or egg-cell of a rabbit, and examine them under a microscope of moderately high magnifying power, we should probably say that the ovum is far more like the amœba than is the vorticella. And yet the rabbit's ovum somehow inherits the power of developing, under appropriate conditions in the maternal uterus, into so wonderfully complicated an organism as that known to zoölogists as *Lepus cuniculus*, a name which sums up peculiarities of structure which it would take a large volume adequately to describe. In some way, which at present we only dimly understand, that little speck of protoplasm, a very pin-point of life, bears the impress of changes wrought on the continuous stream of living substance throughout long ages of geological history. We may wonder how so much potentiality can possibly lie hidden in so little substance—according to some biologists in only a part of the nucleus of the egg—yet, in truth, there is nothing here which is not in principle involved in the fission of the lowly amœba. The essential characteristic of life, on which all this depends, is protoplasmic continuity. This it is which so links the chain of sequence that we may believe, by a legitimate exercise of the faith with which after all science is so abundantly endowed, that changes wrought upon this continuous line of protoplasm so many ages ago still tremble and thrill through its substance to-day. And if we realise that the germinal substance from which the little rabbit develops is (omitting reference to fertilisation) just a little bit of the very same germinal substance from which its mother was in like manner developed, it would be surprising indeed if it grew up into anything very different from that mother.

At the same time though, regarded from the standpoint of science, there are present just the conditions which would give the requisite continuity to form an abiding basis for a prolonged series of antecedent and sequent changes, yet the necessity for assuming some underlying cause, immanent in the fertilised ovum, through the operation of which the sequence in any given case is manifested —this necessity seems to be pressed home on the metaphysician with unusual force. The man of science does and should regard this as outside the problem he sets before himself for solution. But in denying the presence of any such underlying cause, should he do so, he seems to be going beyond his province, and to be overstepping the limits of his boasted agnosticism.

The embryo rabbit is sheltered and nourished within the uterus of its mother and even after birth lies hidden from its enemies and is further nourished and fostered within the burrow. But the frog's spawn which floats on the water of the pond from which we obtained amœba and vorticella is not thus nourished or protected. Each of the little dark beads, within the jelly-like collection of transparent spheres, is a fertilised egg. The frog, like the rabbit, belongs to that extensive and diverse group of animals in which a number of separate or loosely connected particles of living matter are associated together. In the protozoa where the particles or cells have an independent existence the method of reproduction is the separation of a part of that cell for the continuance of the race. In the metazoa to which the frog and the rabbit belong, where there is an aggregation and integration of cells into a complex group with differentiation of function among the many constituent units, we have the distinction into two broadly contrasted groups, —body-cells and germ-cells. The body-cells are classified according to their physiological function into those which subserve the processes of nutrition, respiration, excretion, and so forth. To the germ-cells nature entrusts the essential rôle of reproduction and the continuance of the race. According to modern interpretation the body-cells canot give origin to germ-cells; but it is the essential function of germ-cells, in normal process of development, to give origin to the body-cells of offspring in succeeding generations. Whether the body-cells can in definite ways influence the germ-cells so as to impress upon them, and thus render hereditary, characters which they have themselves acquired, is a question under discussion. In any case, whereas a germ-cell, fertilised in many cases though not in all, by union with another cell produced by a member of the opposite sex, gives rise not only to the bodily framework and diverse tissues of the embryo but also to the germ-cells which may in due course play a similar rôle; the body-cells, though they may divide and subdivide to form other like units, do not, when once fairly started on their special career, give rise to germ-cells capable of reproducing the whole organism. And eventually death is as distinctively their heritage, as continuity of life is the heritage of those which are the bearers of the germinal substance. What we have specially to note, however, is that, notwithstanding the multiplicity of amœba-like units which are associated together to build up the frog, the organism still retains such unity as to justify us in speaking of it as a single individual; and that each germ-cell, duly fertilised, carries on the torch of life which is extinguished by death, throughout the rest of the unity which we term the frog.

The fertilised ovum of the frog contains within the meshes of the network of protoplasm of which it is composed a certain amount of food-yolk, and in the early stages of development this affords material for the protoplasm to assimilate. The nucleus divides and subdivides again and again, and the protoplasm splits into a great number of separate or loosely connected units,—the cells. These gradually differentiate and group themselves into the organs and tissues. During these early stages the frog does not feed; the food-yolk contained in the ovum provides sufficient material for the assimilation of the protoplasm of the differentiating cells,—which do not part company and go each on its own way as in the amœba, but remain associated, merging their individualities in that of a compound organism, each ministering to the others and being ministered to by them for the common good of their joint product. But ere long the minute tadpole is hatched, attaches itself by suckers under the chin to the jelly-like substance in which the eggs were imbedded, or to bits of decomposing animal or vegetable matter, and feeds by means of horny jaws. It obtains oxygen from the water through the instrumentality of gills, and swims like a fish by movements of its tail. Its mode of life, its modes of feeding, breathing, and so forth, are well nigh as different from those of the parent frog as they can be. But all the time it is undergoing changes which gradually fit it for its later life. Lungs and limbs are developing, though for some time they are useless. And so the metamorphosis goes on, until at last, the legs having grown apace, the head and jaws having undergone marked changes, the limbs having acquired a considerable size and some strength, the tail having shrunk to a pointed stump, by a final shedding of the skin the tadpole becomes a frog, and with some further alterations of the relative proportions of its parts, reaches the adult stage of its not uneventful life-history.

Such being in brief outline the facts—which are indeed sufficiently familiar—let us consider their scientific interpretation. They unquestionably present us with a chain of related antecedents and consequents linked into an orderly, consistent, and unified series, marked by a continuity of sequence not less than a diversity of phases. It is in some respects convenient to distinguish among the antecedents those which lie within and those which lie outside the organism; to regard the former as the distinctively vital or essential causes of change, and the latter as the environing or conditioning causes; the environing series having less of direct continuity than the vital. Thus we say that the development at this or that stage proceeds in due course if the conditions are favorable; and that, if the continuity along the developmental line fail and life ceases, this is not due to any lack of causal antecedents in the essentially vital series, but rather to a failure of the contributory aid afforded by the appropriate conditions. We may even say that a cause adequate to produce the effect is present but not the conditions under which alone this cause can be effectual. Convenient as it may be, however, from the biological point of view, to make this distinction—nay, justifiable as it is for the student of life to regard the inner vital cause as essential and the environment as to some extent accidental and merely permissive; still from the broader standpoint of logical scientific interpretation the causal antecedent is to be regarded as the totality of related phenomena which pass insensibly into that other totality of related phenomena which we call the sequent effect. In this way the whole series of events which constitute the life-history of the frog could with adequate knowledge be expressed in terms of related antecedence and sequence; and such expression, when duly generalised by the correlation of this with other life-histories, would afford an adequate and satisfactory explanation of such phenomena from the standpoint of science.

Even supposing this were done, however, there still remains behind a question which would present itself to the metaphysician, though the man of science may be content to ignore it (nay, more, as man of science should resolutely exclude it, as non-scientific). That question would present itself in some such form as this: What is the underlying cause of the sequence which we observe? In other words: Why does this sequent effect issue from that antecedent cause?

Does the theory of biological evolution give an answer to this question? No, it does not. And the more thoroughly it realises its function, the more averse will it be to the pretense of doing so. It does, however, give answers—admittedly imperfect answers, it is true,—to the questions: By what steps has this life-history come to be what it is? What scientific causes have been at work? How has adaptation to environment been reached? I do not propose to discuss these answers; save one, and that very briefly. It is well known that organisms can accommodate themselves to their surrounding conditions, often by acquiring some modification of structure or habit. These are inherited, say some, and the adaptations we see are in large degree the accumulated results of such inheritance, each generation adding a little to the store. According to this answer, then, adaptation is reached by the inheritance of acquired characters. Its efficacy is denied in many quarters, it being contended that the supposed mode of inheritance is unproven. The second answer is summed up in the word selection, or in the phrase "survival of the fittest." This need not here be illustrated. A third answer makes appeal to a principle of orthogenesis; and concerning this answer a few words will not here be out of place.

Professor Eimer has told us through the pages of *The Monist* that orthogenesis is "definitely-directed and law-conforming evolution." He says further that "There is no chance in the transmutation of species. There is unconditioned conformity to law only. Definite evolution, orthogenesis, controls this transmutation. It can lead step by step from the simplest and most inconspicuous beginnings to ever more perfect creations, gradually or by leaps; and the cause of this definite evolution is organic growth." But he also says that the evolutionary advancement of a group of individuals takes place when "they are more sensitive than their fellows to the outward influences that condition the transmutation"—the outward influence referred to being "climatic and nutritional conditions." And again we are told that "the main factor that conditions and promotes the formation of species is the activity, the continued use of certain organs." Now for those who desire carefully to distinguish between scientific and metaphysical causes, these statements of Professor Eimer seem to afford material for analysis. I do not feel equal to the task; but I would urge those who accept orthogenesis, or any form of the doctrine of determinate evolution, seriously to undertake it. Presumably (I speak with hesitation) organic growth as a cause of definite evolution is our old metaphysical friend, Life or Vital Principle. In any case it does not appear much more helpful from the scientific point of view to say that organic growth is the causal antecedent of evolution than to say that evolution is the causal antecedent of organic growth. Organic growth and evolution are for science the group of phenomena of which we seek to understand the conditioning antecedents. What is meant by unconditioned conformity to law under the conditions of climate, nutrition, and exercise, I do not presume even to hazard a guess. The phrase "definite evolution" might, one would suppose, be strictly paralleled by the phrase "definite transmutation"; but, in that case, how definite evolution can control transmutation presents a puzzle unless it is a roundabout way of saying that evolution or transmutation is self-controlling. The word chance would seem to be so used as to imply an absence of "conformity to law" (an implication which Darwin expressly excluded); whereas it should mean conformity to law the particular application of which in the given case eludes our powers of discrimination. Those who have been laboring for a generation to formulate the laws of evolution can hardly be expected to accept the qualification "law-conforming" as specially distinctive of orthogenesis.

It may be said that these are mere verbal criticisms. Let us then go to the heart of the matter. If underlying orthogenesis there is assumed an internal force causing organisms to shoot into certain forms, this is, *quâ* force, a metaphysical conception, and should be frankly stated and regarded as such. In this way the polar forces which control the building of crystals should, I have urged, be stated and regarded. But crystallographers as students of science have done something more than the believers in orthogenesis have yet accomplished, or indeed show hopeful signs of accomplishing. For quite apart from any assumption of underlying forces, they have formulated the laws of crystallographic phenomena, as phenomena, in a way which amply satisfies the requirements of scientific interpretation. Has anything of the sort, even making full allowances for the complexity of the subject-matter, been done by the believers in orthogenesis or determinate evolution? The suggestion that development ceases or halts at certain stages in an apparently arbitrary manner, the observation that the markings of lizards seem to replace one another in the direction from behind forwards, the partial or total disappearance, broadening, and fusion of the fundamental bands on some butterflies' wings, the curious effects of temperature on the colors of lepidoptera, the effects of salinity on certain brine-shrimps, and other cases of apparently definite and determinate transmutations *per saltum*, even granting that the changes of structure are, strictly speaking, hereditary,—these are matters of interest which demand fuller investigation of their antecedent conditions. But can we at present extract from them, after the method of science, anything like broad, stable and widely accepted generalisations—generalisations which force themselves on the acceptance of all who study the facts in a careful, patient, and systematic manner? I think not. I see no *a priori* objection to orthogenesis. On the contrary, it seems reasonable to suppose that since inorganic matter runs into definite forms—simply as a matter of observation—so should organic matter tend to run into *its* definite forms. But reasonable as it may be from the *a priori* point of view, there seems remarkably little *a posteriori* evidence *capable of scientific generalisation.*

And till such is presented, biologists will be well advised to treat with that scepticism, which is the foster-mother of conviction, the suggestions of orthogenesis. And until the scientific position is secure, the metaphysical conception which underlies it partakes to the full of its insecurity. In any case any confusion of the scientific and metaphysical problems, of orthogenesis as an observed fact, and an underlying vital principle which causes it, will, I am convinced, do nothing but darken council and lead the unwary into logical pit-falls.

Reverting then to the life-history of the frog and steadily regarding it from the point of view of biology; granting too all that the most strenuous advocate of the distinctly Darwinian principle can claim from our fund of belief, and adding the results of such additional coöperating factors, orthogenetic or other, as the labors of biologists may place on a sound and logical footing; we may extend the chain of antecedence and sequence into a past that is dimly remote. No matter where we examine the series of events —no matter where we bisect its length by a plane cutting athwart the occurrences of any assignable moment of time, we find that these occurrences are the natural outcome of those which immediately preceded. Whatever metaphysics may have to say, science is assuredly right in holding firmly to its ideal,—the explanation of this as of other life-histories in terms of related antecedence and sequence, every stage in the long and complex process exemplifying the strictest relation of physical and biological cause and effect.

And what more can one desire! the Darwinian enthusiast will exclaim. Given variations of structure and habit, the causes or antecedents of which are ideally ascertainable, if not yet ascertained; given an extravagant output in offspring decimated again and again by the attacks of enemies and the incidence of adverse conditions so that only a favored and well-adapted few survive; given hereditary transmission by which the favorable adaptations to the stern conditions of life are handed on to successive generations and adding other possible coöperating factors, what elements in the problem presented for our study by a given organism remain unsolved, if not actually at all events ideally, by the method of science? Or rising from the particular organism to the generalised principles of biology, when the perfected science of the future shall have said its last word, when we can not only confidently affirm that the totality of life and its conditions to-day is the natural outcome of the life and its conditions of yesterday and will surely give rise to the life and its conditions of to-morrow, but can as confidently describe in all its detail the assemblage of antecedents which constitute the cause and the assemblage of consequents which we name the effect, and can formulate the relationships of the one to the other,—what more remains to be learnt? The problem will be completely solved. No doubt this is only the ideal end to which science is slowly but surely advancing. That we have not reached the ideal is no answer to the claim of science,—which is in effect not that we have solved, but that we can thus solve, and completely solve, the problem of life.

To which the metaphysician will reply that with the supposed extension of our knowledge science will indeed have solved the problem which legitimately lies within its sphere. That problem is: Given life and its environment to describe in particular cases the sequence of events presented by individual development and racial evolution, and by generalising the results so reached to afford a scientific explanation of the phenomena. This is a magnificent problem, and one well worthy of the intellect of Darwin and of his followers. The results so far obtained call forth our sincere admiration and augur well for yet further advances in biological knowledge. But when science shall have said its last word and put the finishing touches on the picture elaborated with so much skill and care, there will still remain the fundamental data of biology presenting another problem with which metaphysics must attempt to deal. When the riddle of development and of evolution shall have been answered in terms of science, the riddle of life will still remain unsolved and insoluble in these terms. The question, What is life? will then as now press for an answer. Such is the counter-claim of the metaphysician.

Now in considering the validity of this claim it must first be asked whether the word *life* is used in quite the same sense by man of science and metaphysician. For if not, there is no limit to the cross-questions and crooked answers which may—which indeed often do—exasperate us by their futility. Let us endeavor clearly to distinguish. As used by the man of science the term *life* comprises an observable sequence of phenomena. We can neither say that life is caused by the phenomena nor that the phenomena are the cause of life. The term is used not with a causal but with a descriptive signification. For the sequence itself is just that which characterises what the biologist terms life. From the strictly biological point of view this group of natural sequences *is* life; and though he may speak of them as the phenomena *of* life, all that is meant by this expression is that this or that particular phenomenon falls within the group to which the term vital is properly applicable. This is a perfectly legitimate and logical position. So in like manner is gravitation a term under which are comprised certain observable movements of inorganic masses. When we say that the fall of a stone to the earth is one of the phenomena of gravitation, what is meant is that this particular fact falls within a certain group. From the strictly physical standpoint the phenomena are neither the cause nor the product of gravitation. For gravity as a cause of motion is a metaphysical conception. Nor are certain other phenomena, those which are studied by the zoölogist, from the strictly biological standpoint either the cause or the product of life. They are simply grouped under this heading.

On the other hand, when the metaphysician uses the term *life*, he has in view the hidden cause or *raison d'être* of the phenomena which the biologist describes under this heading. Let us hear what he has to say in favor of the assumption that such a cause exists. First of all, from a general point of view he urges, as we have seen, that not only has every sequent state a correlative antecedent, but the sequence itself must have a cause. When pressed, however, to lay bare the grounds of this assertion, the metaphysician can only reply that this is a universal postulate of reason; or in other words, that apart from such an assumption the sequence is inexplicable. When further pressed, he is forced to assume that this underlying cause is itself uncaused,—is self-existent. Why then, it may be asked, should we not stop a stage short of that which the metaphysician postulates, and assume that the phenomenal sequence is itself uncaused and self-existent? To which the metaphysician replies: Because the self-existence of phenomena is unthinkable. Is not this, however, some will ask, a verbal quibble? We are led, on the Socratic method, to admit that the observed facts are termed phenomena; we are then bidden to note that the word "phenomena" is equivalent to "appearances"; and having thus fallen into the trap, we are asked by the metaphysician whether they must not logically be appearances of an underlying force which causes them to appear. But there is surely something stronger in the metaphysician's contention than a skilful manipulation of words, more ingenious than ingenuous. The argument really turns not on the use of words but on the nature of experience. Firmly as we may believe in the practical realities of experience and in the orderly sequence of phenomena, we seem forced to confess (*pace* Dr. St. George Mivart) that these practical and proximate realities are only the expression for sense and the scientific knowledge founded thereon, of the ultimate reality which lies beneath and behind them —of which they are the expression or manifestation. In any case, for those—and few modern thinkers will be excluded from their number—who are unable to accept the hypothesis that phenomena are self-existent, there only remain the alternatives of metaphysical agnosticism and of some sort of metaphysical assumption. Either the mode of origin of phenomena is unknowable and may therefore be ignored, or they are caused by some sort of noumenal existence, the nature of which metaphysics may strive to elucidate.

This being in outline the general thesis for which the metaphysician contends he claims that any such elucidation which he attempts should be regarded, not as antagonistic to the assured results of scientific research, but as supplementary to them. Now science in dealing with phenomena is impressed not only with the rich and multifarious diversity of the cosmos but with the fact that it is a cosmos, exhibiting at any rate so much unity as to render broad generalisations applicable to wide stretches of the extensive territory to be surveyed. Metaphysics accepts from science the principle of analysis by which the intersecting strands of the complex web of phenomena are disentangled or traced, across the world-canvas, and the principle of synthesis by which the trend common to groups of strands is expressed in natural law. And although metaphysics tends to lay more stress on the unity of the cosmic cause than on the diversity of manifestation; although it regards analysis as but a means to the ultimate end of synthesis, yet it does not here diverge widely from science in its broader and more philosophical aspect. For science, too, ever strives towards unity of interpretation and aims constantly at a broader and more comprehensive synthesis, to which end its most minute analysis is but an effective means.

Passing now to matters of greater detail metaphysics utilises the work accomplished by science in its analysis of phenomena. Accepting the Newtonian theory of gravitation as applicable to a wide and homogeneous group of observed facts, it urges on the one hand that these facts are inexplicable unless force is assumed as a cause of motion, and on the other hand that this assumption should be regarded as frankly metaphysical, begging thinkers in general and physicists in particular to distinguish carefully between the antecedences and sequences of scientific interpretation and their causes as lying behind or beneath the phenomenal veil; imploring them to place in different categories "force" the mathematical expression of rate of change and "Force" of which this change is the phenomenal expression. So, too, in all cases of interpretation in the wide field of inorganic nature. So long as the chemist deals with combinations, reactions, and dissociations in terms of antecedence and sequence he is stating facts of observation, and by generalising them rises to the laws of chemical change. But when he invokes chemical attractions and affinities, not as the expressions of observed reactions but as the cause of chemical phenomena, he is consciously or unconsciously dipping into metaphysics. So long as the man of science describes the facts and conditions of crystallographic synthesis and bases his generalisations thereon, he is concerned with matters which admittedly fall within his province. But when he invokes the play of crystalline forces to account for the phenomena he is a metaphysician *malgré lui.* For it is the province of metaphysics to search for the causes of which phenomena are the manifestation in experience. Custom has, however, in large degree sanctioned these metaphysical assumptions. And when chemists and physicists talk of their chemical and physical forces as the cause of the attractions or repulsions they observe, few are found to enter a word of protest. It is otherwise when vital phenomena are under consideration. If so much as a hint is expressed of vital force as the cause of physiological phenomena, chemists and physicists who have been talking and writing freely of chemical and physical forces are among the first to be up in arms and are ready to slay with weapons of sharpest scorn the vitalist as a traitor to the cause of science. It is in vain for him to urge that it is only *quâ* metaphysician that he is a vitalist, or that, as man of science, he is content to be a student of phenomena as such. He is branded as a heretic; and his good deeds will scarcely atone for his false faith.

But there are degrees of heresy. There is the heretic who sins rather in word than in thought; and there is the heretic of deeper dye whose mind is fatally perverted. The former is he for whom vital force is merely a convenient expression for the combined action in subtle relations of chemical and physical forces. The latter—he whose case is past praying for—assumes a special mode of causal activity superadded to the play of the chemical and physical forces which he assumes to be also in operation. But if we are to admit any reference to metaphysical forces it is difficult to see what *a priori* grounds there are for rejecting his assumption of a special mode of force-operation in vital phenomena, that is to say, so long as special modes of operation are admitted in dealing with the phenomena of gravitation, cohesion, electrical and chemical actions, crystalline synthesis, and so forth. It would almost seem as if some students of inorganic nature believe that they have worked out a scheme of the forces in operation, and are prepared to proclaim: "Thus far you may go in metaphysical assumption and no farther. *Our* metaphysical assumptions (often, by the way, not recognised as such) are orthodox and admissible; any others are heterodox and altogether damnable." Such an *a priori* attitude savors so strongly of dogmatism that it may be set on one side for the ultramontane pulpits of pseudo-science.

A position deserving of more respectful consideration is taken up by those who urge that there is nothing in the observed facts of biology to justify the assumption of the special operation of a distinctively vital force. Here the metaphysician must accept the data afforded to him by science. He must study at first or second hand the observed phenomena and endeavor to determine whether chemical and physical forces adequately account for them without remainder. He in turn must studiously avoid dogmatism; and even if there seem to be a remainder must invoke a specially vital force only as an hypothesis, the final necessity for which time alone can decide.

Now the question thus suggested is really an exceedingly difficult one to answer. For if vital processes are, as many contend, due to the subtle and intricate interaction of those forces whose simpler and less compounded action is familiar in the inorganic world, this very complexity, precluding, as it does, effective analysis under the conditions presented by the living organism, may be held sufficient to account for any apparent idiosyncrasy in the resultants. On the other hand those who take a different view and contend that in addition to complex physical and chemical reactions, admittedly present, there is a remainder for which these forces fail to render an adequate account, may urge that this complexity serves merely to hide from all but the most searching scrutiny the essentially vital changes with which they are associated. And here lies the peculiar interest and value of the contention so ably put forward by Professor Japp in the address on which I ventured to comment in the last essay. For he there urged that life-products have certain optical properties which imply a selective agency of a kind otherwise unknown,—of a kind which cannot reasonably be attributed to the interaction of forces familiar to the student of chemistry and physics. If this contention be well founded, we have, as Professor Japp points out (though he must not be held responsible for this way of putting it) just the kind of evidence which is held by the metaphysician to justify the assumption of a special vital principle.

But even suppose that criticism and further knowledge render the conception of a specially differentiated vital force untenable, and demonstrate that life-processes owe their peculiarity wholly to certain intricate interactions of chemical and physical forces, it must again be pointed out that the existence of these forces is a metaphysical assumption, and that the term vital may still be conveniently applicable to the peculiarity of this particular mode of interaction which is found nowhere else in nature.

Let us, however, leaving generalities, bring the question down to the level of the practical experience, of, let us say, the embryologist who is dealing with the development of the chick in the egg. First, there is the series of changes in the nucleus of the ovum, the orderly marshalling and splitting of microscopic rods of deeply staining substance, and all the subtle attractions and repulsions involved in the maturation of the reproductive cell; next there is the further series of changes accompanying the union of sperm-nucleus and egg-nucleus in the process of fertilisation when the attractions have all the appearance of being highly special in their nature and peculiar not only to life but to this particular phase of life. Then there is the repeated division of the new combined nucleus and the formation of the superficial patch of delicate skin-like tissue known as the blastoderm; and following this the gradual differentiation of cell-products into the three layers from which all the organs and tissues are formed by further differentiation of structure with physiological division of labor. We need not follow the familiar stages of development in detail, the origin of blood-vessels and blood-cells, the formation of the axial supporting rod or notochord, the establishment of the central nervous system, the outgrowth of efferent and the ingrowth of afferent nerve-axes, the development of sense-organs, the setting aside of patches of relatively undifferentiated cells in the lining of the body-cavity for reproductive purposes, the differentiation of the kidneys and their ducts and the closely associated ducts of the reproductive system, all the orderly outgrowths from the alimentary tube with the formation of lungs, liver, and pancreas, the establishment of cartilage and its conversion into duly related bones, the production by the skin of claws, beak, and down-feathers, and in general all the differentiations of cell-structure and cell-products which, under appropriate conditions of warmth and moisture, accompany the passage from the relatively simple egg into that marvellous going concern which emerges as a chick.

Now we must once more distinguish, even at the risk of wearisome reiteration, between the scientific explanation of these phenomena and the metaphysical implications which they may (or may not) suggest. Granted that the whole series of changes is an orderly sequence; granted that a full knowledge of any one stage would enable us accurately to predict the next stage on the basis of previous experience; granted that an adequate study of this and many other particular cases of development would enable us to formulate the generalised results of the knowledge gained by experience in the form of embryological laws; granted that by yet further extension of our knowledge the whole, on deeper analysis, could be expressed in terms of the movements of material particles, atomic or molecular; granted that the laws of the character and rate of these movements could be duly formulated; granted finally that the whole series of evolutional changes, stretching back into a dim and remote past, could be summed up and presented to the eye and the intellect of science; then the whole problem would be completely solved from the strictly scientific standpoint without the introduction of a single metaphysical assumption. We are indeed at present far enough off from any such complete solution; but any objection based on such grounds may be ruled out as not to the point. If the groundwork and foundations of our science are secure —and this groundwork is (again *pace* Dr. Mivart) not composed of metaphysical assumptions but of the data and laws of experience— such a solution may be foreseen, if never reached, by carrying the curve of scientific progress to its ideal limit. Here science reaches the end of its tether. Its range is surely wide enough to satisfy the hungriest of scientific appetites. But the intellect of man is omnivorous and not to be satisfied. It says: "Notwithstanding this rich table of knowledge you set before me, I still have a craving for another kind of food,—the reason of it all; what makes the particles move as we see them move; what drives the wheels of life, as it drives the planets in their courses; what impels the egg to go through its series of developmental changes; what hurries on the frog through its strange life-history?" Now, the answer of metaphysical agnosticism to all this is simply: We don't know; which is an honest confession of ignorance. The answer of the scoffer is: I don't care; which sounds strange from the lips of a rational being. The answer of the metaphysician at the present stage of our inquiry is, Force. This Force is assumed to be self-existent. Phenomenal sequence is regarded as the effect; noumenal Force the cause. It is pure assumption and may be safely disregarded by the man of science as such.

But if we introduce the conception of Force at all; if we speak of physical and chemical forces, let us be consistent and assume the omnipresence of Force throughout the universe of phenomena. The development of the egg, not less than the fall of a stone or the formation of a chemical compound, must be attributed to Force in general and to the play of forces in detail. Whether the sequence of embryological changes, hinted at rather than described above, necessitates a special manifestation of Force, termed vital, or a special mode of synthesis, which may also be termed vital, or simply expresses the resultants of a complex interaction of forces familiar in the inorganic sphere, we will not attempt to determine. The scientific data on which alone metaphysics can base its conclusions are insufficient. This, however, we may affirm: that if the conception of Force be introduced in any form, it is introduced as a metaphysical assumption; and if there be a special vital force, or a specially vital combination of inorganic forces—that is to say, differential modes of manifestation of the self-existent Cause—there is nothing here that may not be paralleled in other parts of the realm of nature. But, in the interests alike of science and of metaphysics, let us above all things distinguish carefully the problems of the one from the problems of the others.

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